

Amendments to the Claims:

Please cancel claims 1616, 1658, and 5408 without prejudice.

This listing of claims will replace all prior versions and/or listings of claims in the application:

1-1607. (cancelled)

1608. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters positioned in heater wells to at least a ~~portion~~ section of the formation;

allowing the heat to transfer from the one or more heaters to a part of the formation;

wherein the part of the formation has been selected for heating using an atomic hydrogen weight percentage of at least a portion of hydrocarbons in the part of the formation, and wherein at least the portion of the hydrocarbons in the part of the formation comprises an atomic hydrogen weight percentage, when measured on a dry, ash-free basis, of greater than about 4.0 %; and

pyrolyzing hydrocarbons in the part of the formation;

controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range of about 270 °C to about 400 °C; and
producing a mixture from the formation.

1609. (previously presented): The method of claim 1608, wherein the one or more heaters comprise at least two heaters, and wherein controlled superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

1610. (previously presented): The method of claim 1608, further comprising maintaining a temperature in the part of the formation in a pyrolysis temperature range of about 270 °C to about 400 °C.

1611. (previously presented): The method of claim 1608, wherein at least one of the one or more heaters comprises an electrical heater.

1612. (cancelled)

1613. (previously presented): The method of claim 1608, wherein at least one of the one or more heaters comprises a flameless distributed combustor.

1614. (previously presented): The method of claim 1608, wherein at least one of the one or more heaters comprises a natural distributed combustor.

1615. (previously presented): The method of claim 1608, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1616. (cancelled)

1617. (currently amended): The method of claim 1608, wherein providing heat from the one or more heaters to at least the ~~portion~~section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more of the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

1618. (original): The method of claim 1608, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

1619. (previously presented): The method of claim 1608, wherein allowing the heat to transfer to the part of the formation heats the part of the formation to increase a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C).

1620. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1621. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1622. (original): The method of claim 1608, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1623. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1624. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1625. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1626. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1627. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1628. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1629. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1630. (original): The method of claim 1608, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

1631. (currently amended): The method of claim 1608, wherein the produced mixture comprises a non-condensable component that does not condense at 25° C and one atmosphere absolute pressure, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

1632. (original): The method of claim 1608, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1633. (original): The method of claim 1608, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1634. (previously presented) The method of claim 1608, further comprising controlling a pressure in at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bars absolute.

1635. (previously presented): The method of claim 1608, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

1636. (previously presented): The method of claim 1635, wherein the partial pressure of H₂ in the mixture is measured when the mixture is at a production well.

1637. (previously presented): The method of claim 1608, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1638. (original): The method of claim 1608, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

1639. (previously presented): The method of claim 1608, further comprising:
providing hydrogen (H₂) to the heated part of the formation to hydrogenate hydrocarbons in the part of the formation; and
heating a portion of the part of the formation with heat from hydrogenation.

1640. (original): The method of claim 1608, further comprising:

producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion
of the produced hydrogen.

1641. (previously presented): The method of claim 1608, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 250 millidarcy.

1642. (previously presented): The method of claim 1608, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part is substantially uniform.

1643. (original): The method of claim 1608, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1644. (previously presented): The method of claim 1608, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

1645. (previously presented): The method of claim 1608, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

1646. (previously presented): The method of claim 1608, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1647. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters positioned in heater wells to at least a ~~portion~~ section of the formation;

allowing the heat to transfer from the one or more heaters to a part of the formation;

wherein at least some hydrocarbons in the part of the formation have an initial atomic hydrogen weight percentage of greater than about 4.0 %; ~~and~~

wherein allowing the heat to transfer to the part of the formation heats the part of the formation to increase a thermal conductivity of at least a portion of the part of the formation to greater than about 0.5 W/(m °C); and

producing a mixture from the formation.

1648. (previously presented): The method of claim 1647, wherein the one or more heaters comprise at least two heaters, and wherein controlled superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the part of the formation.

1649. (previously presented): The method of claim 1647, further comprising maintaining a temperature in the part of the formation in a pyrolysis temperature range of about 270 °C to about 400 °C.

1650. (previously presented): The method of claim 1647, wherein at least one of the one or more heaters comprises an electrical heater.

1651. (cancelled)

1652. (previously presented): The method of claim 1647, wherein at least one of the one or more heaters comprises a flameless distributed combustor.

1653. (previously presented): The method of claim 1647, wherein at least one of the one or more heaters comprises a natural distributed combustor.

1654. (previously presented): The method of claim 1647, further comprising controlling a pressure and a temperature in at least a majority of the part of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

1655. (previously presented): The method of claim 1647, further comprising pyrolyzing hydrocarbons in the part of the formation, and controlling the heat such that an average heating rate of the part of the formation is less than about 1 °C per day in a pyrolysis temperature range of about 270 °C to about 400 °C.

1656. (currently amended): The method of claim 1647, wherein providing heat from the one or more heaters to at least the ~~portion~~section of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more of the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

1657. (original): The method of claim 1647, wherein allowing the heat to transfer comprises transferring heat substantially by conduction.

1658. (cancelled)

1659. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons having an API gravity of at least about 25°.

1660. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 0.1 % by weight to about 15 % by weight of the condensable hydrocarbons are olefins.

1661. (original): The method of claim 1647, wherein the produced mixture comprises non-condensable hydrocarbons, and wherein a molar ratio of ethene to ethane in the non-condensable hydrocarbons ranges from about 0.001 to about 0.15.

1662. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is nitrogen.

1663. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is oxygen.

1664. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 1 % by weight, when calculated on an atomic basis, of the condensable hydrocarbons is sulfur.

1665. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons comprise oxygen containing compounds, and wherein the oxygen containing compounds comprise phenols.

1666. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein greater than about 20 % by weight of the condensable hydrocarbons are aromatic compounds.

1667. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 5 % by weight of the condensable hydrocarbons comprises multi-ring aromatics with more than two rings.

1668. (original): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein less than about 0.3 % by weight of the condensable hydrocarbons are asphaltenes.

1669. (previously presented): The method of claim 1647, wherein the produced mixture comprises condensable hydrocarbons, and wherein about 5 % by weight to about 30 % by weight of the condensable hydrocarbons are cycloalkanes.

1670. (currently amended): The method of claim 1647, wherein the produced mixture comprises a non-condensable component that does not condense at 25° C and one atmosphere absolute pressure, wherein the non-condensable component comprises molecular hydrogen, wherein the molecular hydrogen is greater than about 10 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure, and wherein the molecular hydrogen is less than about 80 % by volume of the non-condensable component at 25 °C and one atmosphere absolute pressure.

1671. (original): The method of claim 1647, wherein the produced mixture comprises ammonia, and wherein greater than about 0.05 % by weight of the produced mixture is ammonia.

1672. (original): The method of claim 1647, wherein the produced mixture comprises ammonia, and wherein the ammonia is used to produce fertilizer.

1673. (previously presented): The method of claim 1647, further comprising controlling a pressure in at least a majority of the part of the formation, wherein the controlled pressure is at least about 2.0 bars absolute.

1674. (previously presented): The method of claim 1647, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H₂ in the mixture is greater than about 0.5 bar.

1675. (previously presented): The method of claim 1674, wherein the partial pressure of H₂ in the mixture is measured when the mixture is at a production well.

1676. (previously presented): The method of claim 1647, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

1677. (original): The method of claim 1647, further comprising controlling formation conditions by recirculating a portion of hydrogen from the mixture into the formation.

1678. (previously presented): The method of claim 1647, further comprising:
providing hydrogen (H₂) to the heated part of the formation to hydrogenate hydrocarbons in the part of the formation; and
heating a portion of the part of the formation with heat from hydrogenation.

1679. (original): The method of claim 1647, further comprising:
producing hydrogen and condensable hydrocarbons from the formation; and
hydrogenating a portion of the produced condensable hydrocarbons with at least a portion of the produced hydrogen.

1680. (previously presented): The method of claim 1647, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation to greater than about 250 millidarcy.

1681. (previously presented): The method of claim 1647, wherein allowing the heat to transfer increases a permeability of a majority of the part of the formation such that the permeability of the majority of the part of the formation is substantially uniform.

1682. (original): The method of claim 1647, further comprising controlling the heat to yield greater than about 60 % by weight of condensable hydrocarbons, as measured by the Fischer Assay.

1683. (previously presented): The method of claim 1647, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

1684. (previously presented): The method of claim 1647, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, and wherein the unit of heaters comprises a triangular pattern.

1685. (previously presented): The method of claim 1647, further comprising providing heat from heaters to at least a portion of the formation, wherein the heaters are located in the formation in a unit of heaters, wherein the unit of heaters comprises a triangular pattern, and wherein a plurality of the units are repeated over an area of the formation to form a repetitive pattern of units.

1686-5395. (cancelled)

5396. (previously presented): The method of claim 1644, wherein at least about 20 heaters are disposed in the formation for each production well.

5397. (previously presented): The method of claim 1683, wherein at least about 20 heaters are disposed in the formation for each production well.

5398. (previously presented): The method of claim 1608, wherein the part of the formation comprises a pyrolysis zone.

5399. (previously presented): The method of claim 1647, wherein the part of the formation comprises a pyrolysis zone.

5400. (currently amended): A method of treating a hydrocarbon containing formation in situ, comprising:

providing heat from one or more heaters positioned in heater wells to at least a ~~portion~~ part of the formation;

allowing the heat to transfer from the one or more heaters to a selected section of the formation;

wherein at least some hydrocarbons in the selected section have an initial atomic hydrogen weight percentage of greater than about 4.0 %; and

controlling a pressure in at least a majority of the selected section, wherein the controlled pressure is at least about 2.0 bars absolute; and

producing a mixture from the formation.

5401. (cancelled)

5402. (previously presented): The method of claim 5400, wherein the one or more heaters comprise at least two heaters, and wherein controlled superposition of heat from at least the two heaters pyrolyzes at least some hydrocarbons in the selected section.

5403. (previously presented): The method of claim 5400, further comprising maintaining a temperature in the selected section in a pyrolysis temperature range of about 270 °C to about 400 °C.

5404. (previously presented): The method of claim 5400, wherein at least one of the one or more heaters comprises a natural distributed combustor.

5405. (previously presented): The method of claim 5400, further comprising controlling a pressure and a temperature in at least a majority of the selected section of the formation, wherein the pressure is controlled as a function of temperature, or the temperature is controlled as a function of pressure.

5406. (previously presented): The method of claim 5400, further comprising pyrolyzing hydrocarbons in the selected section and controlling the heat such that an average heating rate of the selected section is less than about 1 °C per day in a pyrolysis temperature range of about 270 °C to about 400 °C.

5407. (currently amended): The method of claim 5400, wherein providing heat from the one or more heaters to at least the ~~portion~~ part of the formation comprises:

heating a selected volume (V) of the hydrocarbon containing formation from one or more of the heaters, wherein the formation has an average heat capacity (C_v), and wherein the heating pyrolyzes at least some hydrocarbons in the selected volume of the formation; and

wherein heating energy/day (Pwr) provided to the selected volume is equal to or less than $h * V * C_v * \rho_B$, wherein ρ_B is formation bulk density, and wherein an average heating rate (h) of the selected volume is about 10 °C/day.

5408. (cancelled)

5409. (previously presented): The method of claim 5400, further comprising controlling formation conditions to produce the mixture, wherein a partial pressure of H_2 in the mixture is greater than about 0.5 bar.

5410. (previously presented): The method of claim 5400, further comprising altering a pressure in the formation to inhibit production of hydrocarbons from the formation having carbon numbers greater than about 25.

5411. (previously presented): The method of claim 5400, wherein producing the mixture comprises producing the mixture in a production well, and wherein at least about 7 heaters are disposed in the formation for each production well.

5412. (previously presented): The method of claim 5400, wherein at least about 20 heaters are disposed in the formation for each production well.

5413. (new): The method of claim 1608, further comprising providing hydrogen (H_2) to the heated part of the formation.

5414. (new): The method of claim 5400, further comprising providing hydrogen (H_2) to the heated part of the formation.

5415. (new): The method of claim 5400, further comprising providing hydrogen (H_2) to the heated part of the formation to hydrogenate hydrocarbons in the formation.